Improvement of Mesoscale Numerical Weather Prediction For Coastal Regions of Complex Terrain FY2003

Clifford F. Mass
Department of Atmospheric Sciences
Box 351640
University of Washington
Seattle, Washington 98195
phone: (206) 685-0910 fax: (206) 543-0308 email: cliff@atmos.washington.edu

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http://www.atmos.washington.edu/

LONG-TERM GOALS

The long-term goals of this effort are two-fold: (1) to improve understanding of gap flows and other coastal orographic features using both observations and numerical modeling, and (2) to evaluate the effectiveness of high-resolution NWP over a region with coastal orography, using both deterministic and probabilistic (ensemble) methods.

OBJECTIVES

The major scientific objectives of the project include the following:

* To study gap flow in and near coastal orography. This work is directed towards understanding the structures and dynamics of gap flows, as well as an evaluation of the skill of high-resolution numerical weather prediction models in realistically simulating gap winds. Particular emphasis is given to the Columbia River Gorge, a mesoscale gap with an unusually dense array of surface observations and little bottom slope.

* Evaluation of the value of mesoscale ensembles created by both varying initializations and model physics. Although there have been a number of studies of the ensemble approach, few have examined mesoscale ensembles over coastal regions or in areas with substantial terrain. Another objective is to test a different approach to ensemble generation: using variations in initializations and boundary conditions from the forecasts of different operational centers.

* To help determine the implications of a "next-generation" local mesoscale forecasting capability for regional Navy operational needs, and to help train Navy personnel in the use of high-resolution model forecasts.

APPROACH

We are well into a detailed study of the structure, dynamics and modeling of gap flow, with particular attention to the Columbia River Gorge. Observational analyses are being made for a number of Gorge

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gap flow cases, using surface observations, radar data, and ACARS aircraft data from flights approaching and leaving Portland. A climatological analysis using stations around the Gorge has been constructed to determine the mean effects of such a mesoscale gap. A substantial effort has gone into modeling the Gorge flow at ultra high resolution (down to .44 km grid spacing) using the Penn. State/NCAR mesoscale model (MM5) to determine the potential for modeling such gap flow and for determining what horizontal/vertical resolutions and physics options are required. Finally, the high-resolution numerical model output is being used to study the structural evolution, dynamics, and trajectories associated with Gorge flow.

An ensemble prediction system has been created that runs the MM5 at 36 and 12-km resolution several times using different initializations and lateral boundary conditions (NCEP AVN, ETA, MRF and Navy NOGAPS, Australian GASP, Taiwanese Global Model, UKMET Office global model, and the Canadian GEM model) as well as three additional physics diversity runs (varying PBL schemes, microphysics and cumulus parameterizations). In addition, eight additional runs are being made by using a new "mirroring" approach in which initializations are projected around the ensemble mean. These runs are made daily (0000 UTC cycle) and are being carefully verified against regional observations. The skill of the ensemble mean and the relationship of forecast skill and spread have been examined in great detail.

WORK COMPLETED AND RESULTS

Specific ONR-supported accomplishments during the past year includes:

1. The 20 member mesoscale ensemble system has been created, made operational, and its output is available in real-time on the web. We have put into place a verification system and have begun analyzing the results. Our initial evaluation shows that mesoscale detail is apparent in the ensemble mean and that the ensemble mean has generally been more skillful than any individual member. Even more important, we have found that the ensemble system is capable of forecasting model skill, with the spread of the ensemble forecasts closely related to the forecast skill of the ensemble mean AND each individual member. Another task has been to use the ensembles to create probabilistic guidance. One paper has been published on this work (Grimit and Mass 2002) and another is being written. A sample of our results, showing the relationship of spread and skill is found in the figure below.

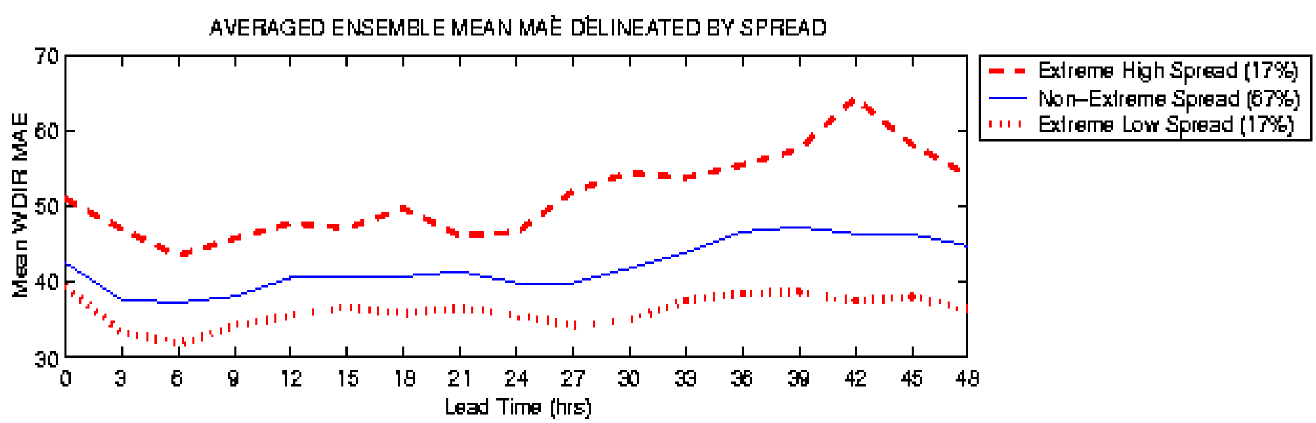

Figure 1: Ensemble-mean mean absolute error for wind direction. The high spread events (top 17% spread) have far larger errors than the low spread cases.

2. Substantial progress has been made in observational and modeling studies of the flow through the Columbia River Gorge. The Gorge is an ideal test bed for the study of gap flows due to its simple geometry and substantial data assets. Our work has revealed improved simulations as horizontal resolution is increased from 4 to 1.3 to .44 km grid spacing. However, there does appear to be a point of diminishing returns with 1.3 km being the coarsest resolution that adequately handles the 5-10 km wide gap. An important finding is that the low-level winds are greatest over the western exit of the Gorge, NOT at the point of constriction. Our results show that unlike conventional "wisdom," the major forcing of gap flow is the collapse of the cold air exiting the gap, not a constriction related venturi effect. The collapse of the cold air produces a low-level pressure gradient that accelerates the winds in the exit region. The figure below, showing a vertical cross section across the gap, illustrates this cold air collapse.

3. A high level of interaction has been fostered between the UW group and Navy operational personnel at Whidbey Island NAS. This interaction has included the provision of the MM5 real-time forecasts, forecast discussions over the telephone, and several meetings with Whidbey personnel. The knowledge garnered from this effort has been transferred to a gap wind chapter for the Navy Mesoscale Primer (the PI is the author of this section).

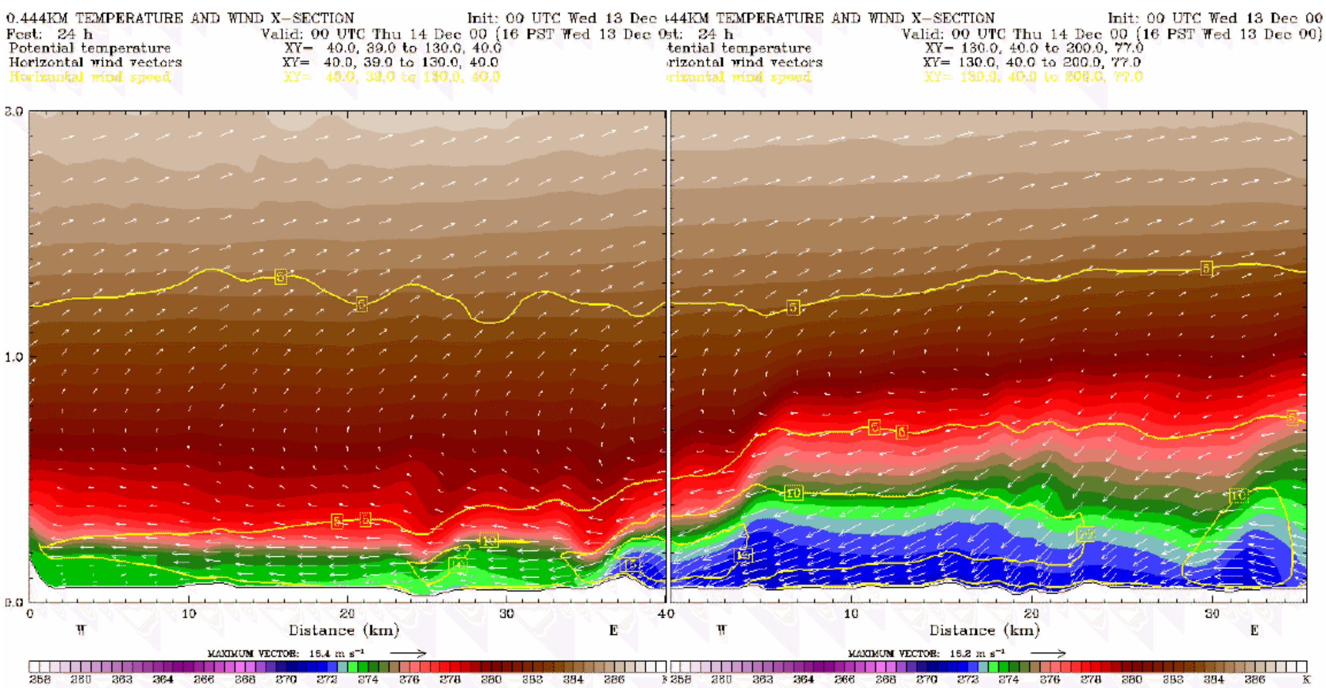

Figure 2: An east-west vertical cross section along the Columbia River Gorge from a 24-h MM5 simulation. Shading shows potential temperature and wind are indicated by vectors. Note how the depth of the cold air originating in eastern Washington collapses over the western exit of the Gorge. Winds greatly increase in this region.

IMPACT/APPLICATIONS

This work provides the best documentation to date of the dynamics and structures in near-sea level coastal gaps. It also represents the most complete evaluation to date of mesoscale ensembles over coastal regions with terrain.

TRANSITIONS

Judged by citations, the above work has had a substantial influence on other groups involved in the study of coastal circulations in complex terrain. The predictions produced by this effort have been used by local Navy meteorologists in the Northwest (e.g., Whidbey, Bangor) and the resulting publications provide a substantially updated view of gap flow to the general community. The PI is the author of the section in the Navy mesoscale primer on gap flows and thus the Navy operational community is assisted by this research effort.

REFERENCES

Publications sponsored in total or part by this grant during the last year include:

Sharp J., and C. F. Mass, 2003: Gap Flow in the Columbia Gorge, Part 1. Submitted to Weather and Forecasting.

McMurdie, L., and C. F. Mass, 2003: Major Numerical Forecast Failures in the Northeast Pacific and North American West Coast. Major forecast failures over the eastern Pacific. Accepted in *Weather and Forecasting.*

C. F. Mass et al;. 2003: IFPS and the Future of the National Weather Service. *Weather and Forecastin*g, **18**, 75-79

C. F. Mass et al;. 2003: Regional Environmental Prediction over the Pacific Northwest Prototype. Accepted in *Bull. Amer. Meteor. Soc.*

Sharp, J., and C. F. Mass, 2002: Columbia Gorge flow: insights from observational analysis and ultra-high resolution model simulation. *Bull. Amer. Meteor. Soc*., 18, 75-79

Grimit, E. P., and C. F. Mass, 2002: Initial results of a mesoscale short-range ensemble forecasting system over the Pacific Northwest, *Weather and Forecasting*, **17**, 192–205

Mass, C., D. Ovens, M. Albright, and K. Westrick, 2002: Does Increasing Horizontal Resolution Produce Better Forecasts?: The Results of Two Years of Real-Time Numerical Weather Prediction in the Pacific Northwest. *Bull. Amer. Meteor. Soc.,* **83,** 407–430.